

Paper

A New CPW-fed Patch Antenna for UWB Applications

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Abstract—In this paper, the design and analysis of a compact size coplanar waveguide (CPW)-fed antenna for ultra-wideband (UWB) applications is presented. The antenna has a compact size of $20 \times 20 \times 1.5$ mm and provides a good impedance matching over the entire bandwidth of 3.2–14.3 GHz. The characteristics parameters, i.e. return loss, VSWR and radiation pattern, are analyzed using HFSS 11.0 software.

Keywords—planar antenna, ultra wideband, wireless communication.

1. Introduction

Ultra-Wide Band (UWB) technology is best suitable candidate for future communication systems, i.e. vehicular radar system (20–29 GHz), due to its advantages like low power consumption, low cost for short range communication and highly secure communication [2]. UWB antennas have wide application in wireless communication, medical equipment, remote sensing, etc. A challenge while designing UWB antenna is to achieve compact size, good impedance over wide bandwidth and stable radiation pattern [2]. Multiband antenna is proposed for similar applications in [3].

2. Related Work

In literature a variety of UWB antennas have been reported, i.e. CPW-fed compact, which gives wide 2.6–13.04 GHz bandwidth [4]. In [5], an UWB antenna with slotted radiating patch has been demonstrated. In [6] an optimization algorithm based ultra wideband antenna is presented. A triangular shaped ground plane based antenna suitable for UWB communication has been reported in [7]. Si *et al.* have used circular disc and split ring resonator to design UWB aerial with 182% wider bandwidth [8]. The concept of coupling between rectangular slot and tuning stub has been utilized to achieve UWB performance in [9]. In [10], a radiating patch with arc-shaped ground plane has been demonstrated, which is suitable for ultra-wideband applications.

The hexagonal-shaped microstrip fractal antenna powered through CPW-fed structure for UWB applications has been reported in [11]. A rectangular-shaped compact CPW-fed antenna has been demonstrated which is suitable for UWB and WLAN applications [12]. Another slotted

rectangular patch antenna for WLAN application is presented in [13]. This has a simple structure and bandwidth of 2.06 GHz. For portable mobile communication, a tapered patch and ground plane with slots is presented, which gives 164% wider bandwidth [14].

3. Design of Proposed Antenna

The proposed slotted CPW-fed patch made on a FR4 glass-epoxy laminate is presented in Fig. 1.

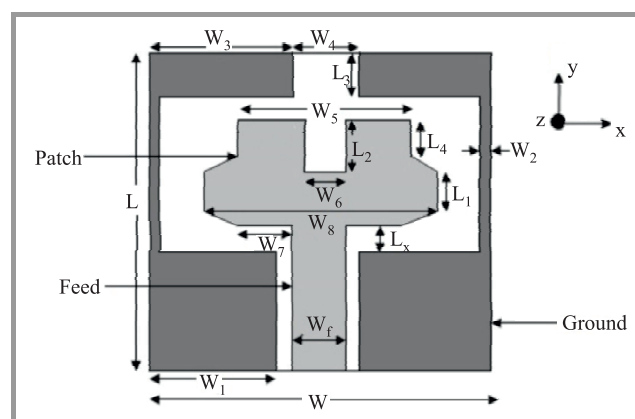


Fig. 1. Geometry of proposed CPW-fed patch antenna.

In design a 20×20 mm, substrate size was considered as requirement. The single side height is typical 1.5 mm, with dielectric constant 4.4 and loss tangent 0.02. Slotted rectangular patch is chosen to achieve wide impedance bandwidth in planar antennas. The patch size is of 6×15 mm wider. Two equal finite ground planes are placed on each side of the CPW-fed, extended upward to utilize the area (Fig. 1). The CPW-fed is used as it provides less radiation loss together with low dispersion and good impedance matching. The coplanar waveguide fed is in the x-z plane. The width of the CPW-fed line is fixed at 3 mm to achieve 50Ω characteristic impedance. The feed line length is 9 mm. The whole dimensions are listed in Table 1.

4. Simulation and Results

To evaluate antenna performance, a simulation study is carried out using finite element method based HFSS 11.0 software. The parameters like return loss, VSWR, current dis-

Table 1
Antenna dimensions

Parameter	W_1	W_2	W_3	W_4	W_5	L_1	L_x	W_7	W_8	L_4
Value [mm]	8.1	0.5	7	6	11	2	1	4	15	2

tribution and radiation pattern are obtained. In order to improve the antenna performance, the parametric study is carried out. The parameters chosen for parametric study are slot width W_6 , slot length L_2 and ground plane length L_3 . The other values have no significant contribution in the performance characteristics and are kept constant as indicated in Table 1. Figures 2–4 show the simulation results of return loss at different values.

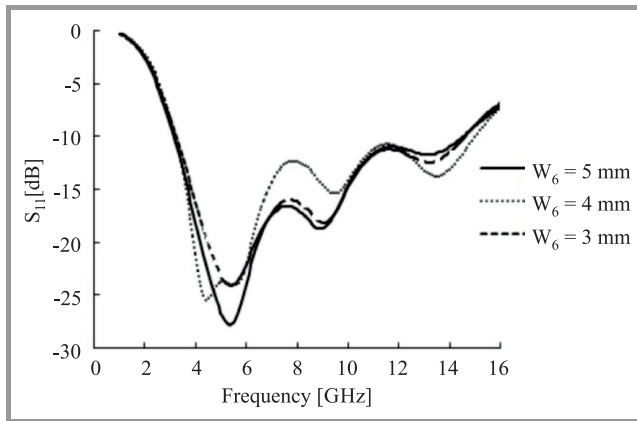


Fig. 2. Effect of slot width W_6 on return loss for $L_2 = 1.5$ mm and $L_3 = 0.5$ mm.

Figure 2 shows the effect of different slot width W_6 on return loss. This parameter affects the return loss characteristics over the entire bandwidth. The minimum values of return loss was observed by keeping $W_6 = 5$ mm. The return loss values are -27.8 , -18.2 and -12.5 dB at 5.3, 9, and 13.2 GHz, respectively.

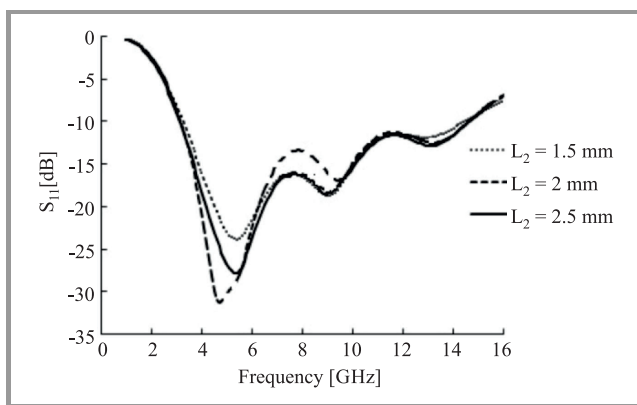


Fig. 3. Effect of slot length L_2 on return loss S_{11} for $W_6 = 5$ mm and $L_3 = 0.5$ mm.

The effect of varying slot length L_2 on return loss is shown in Fig. 3. This parameter affects the performance of antenna near lower operating frequency. A significant change in

results can be observed with change in L_2 . The desired performance is found for $L_2 = 2.5$ mm. The values of return losses are -24 , -18.7 and -12 dB at 5.4, 9, and 12.9 GHz, respectively.

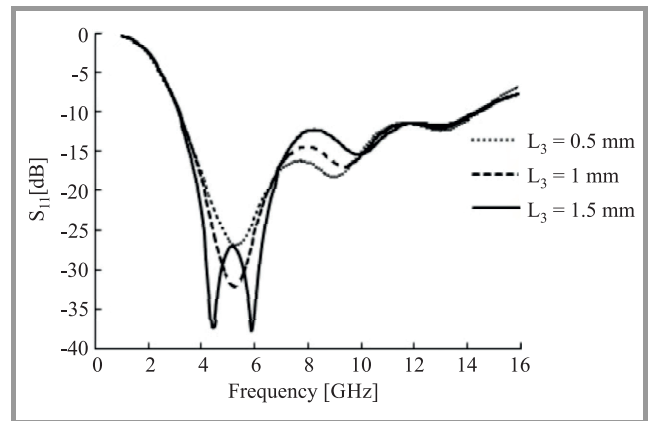


Fig. 4. Effect of ground plane length L_3 on return loss for $W_6 = 5$ mm and $L_2 = 2.5$ mm.

The ground plane length also has an impact on antenna performance as shown in Fig. 4. It can be seen that by keeping $L_3 = 1.5$ mm three significant bands are observed. The corresponding return loss values are -37.1 , -37.6 and -15.4 dB at 4.5, 5.9, and 10 GHz, respectively.

Figure 5 shows the antenna performance by keeping optimized parameter values as $L_2 = 2.5$, $L_3 = 1.5$ and $W_6 = 5$ mm. This antenna gives a wideband performance over an entire range of 3.2–14.3 GHz. Three significant bands are obtained at 4.5, 5.9 and 10 GHz. It has three dominant frequencies at 4.5, 5.9, and 10 GHz and the overlapping of these make the suitable for UWB.

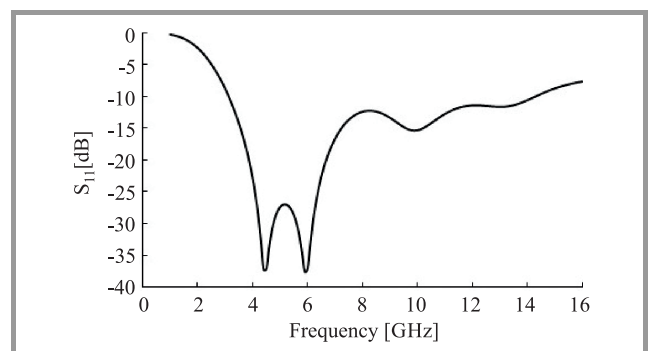


Fig. 5. Simulated return loss for optimized parameters.

While comparing the similar type of aerials existing in the literature, the proposed antenna shows an improvement of 6–27% [4], [9] in bandwidth.

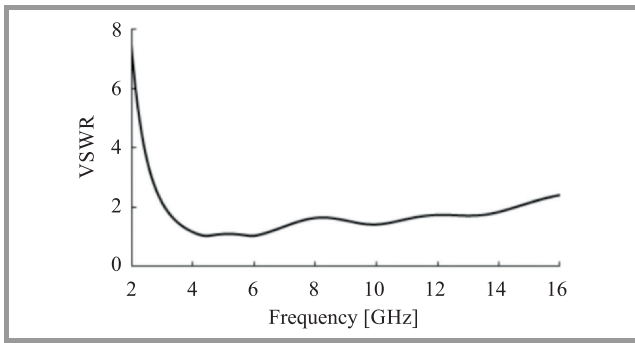


Fig. 6. VSWR versus frequency plot of proposed antenna.

In addition, the proposed antenna performance in terms of VSWR is shown in Fig. 6. The values of VSWR are 1.1, 1 and 1.41 at 4.5, 5.9, and 10 GHz, respectively. The 2:1 VSWR bandwidth is 11.1 GHz.

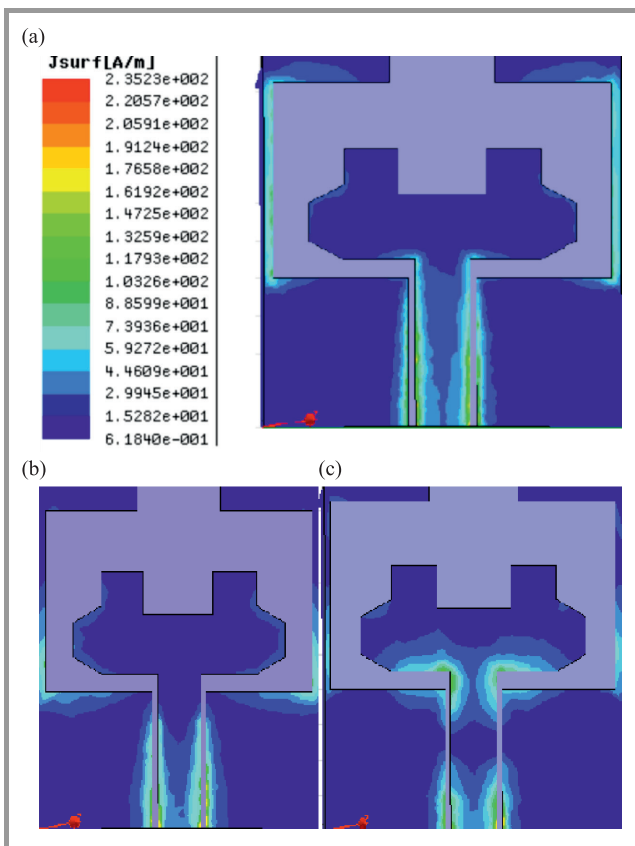


Fig. 7. Surface current flow on the antenna at: (a) 4.5, (b) 5.9, and (c) 10 GHz. (See color pictures online at www.nit.eu/publications/journal-jtit)

Figure 7 presents the current distribution at different resonant frequencies: 4.5, 5.9, and 10 GHz. At 4.5 GHz, the electric current density is concentrated mainly on the side and upper edges of the ground plane, lower portion of patch and feed line. As shown in Fig. 7b, at 5.9 GHz current distribution is mainly concentrated on the side edges of patch, side vertical edges of ground plane and feed line. At 10 GHz current density is mainly concentrated on the patch and feed line as shown in Fig. 7c.

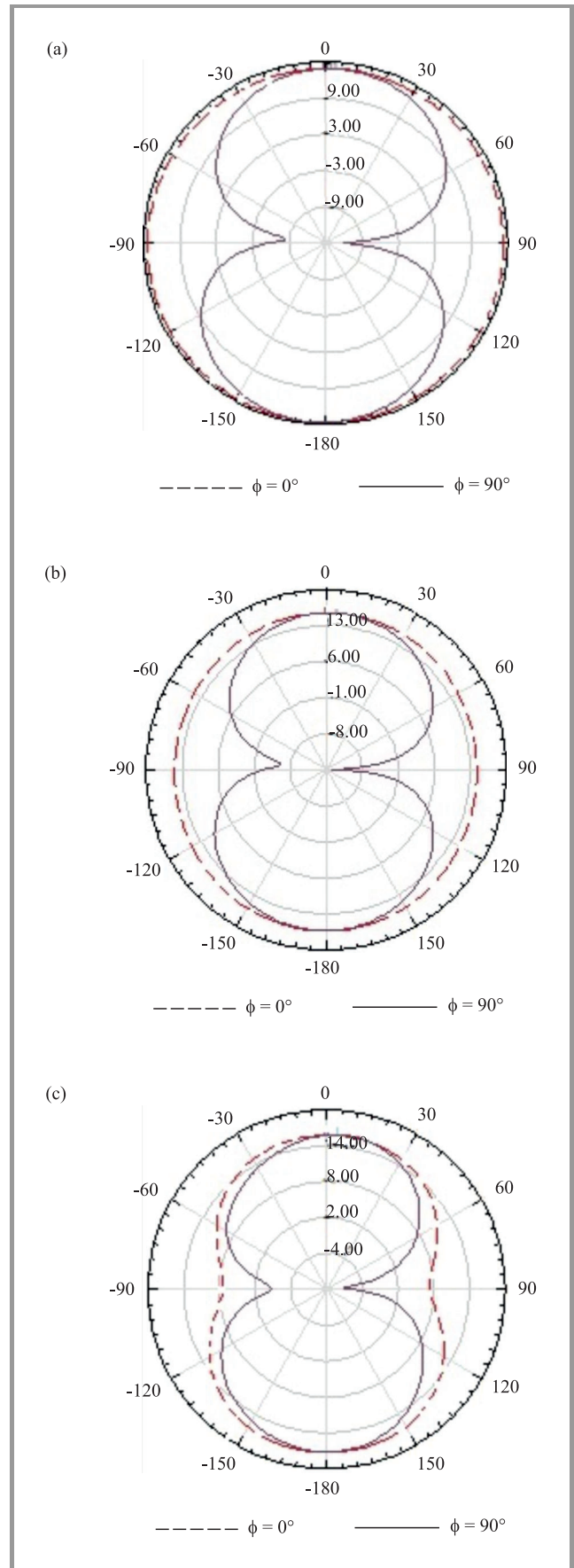


Fig. 8. Radiation pattern plots of designed antenna at: (a) 4.5, (b) 5.9 and (c) 10 GHz.

Radiation pattern plots for designed antenna at 4.5, 5.9 and 10 GHz are presented in Fig. 8. The simulated peak gains are 13.9, 15.4 and 15.7 dBi respectively at 4.5, 5.9 and 10 GHz. One can found that the antenna has nearly good omnidirectional radiation pattern at 4.5 and 5.9 GHz frequencies. At 10 GHz the radiation pattern is deviated from that of omnidirectional.

5. Conclusion

In this paper, a new small size UWB antenna is proposed and analyzed. The antenna shows a good impedance bandwidth over the entire operating band of 3.2–14.3 GHz. Due to the compact size, wide impedance bandwidth, and nearly omnidirectional radiation properties, it is a good candidate for the applications in wireless communication.

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